**Statistical Thermodynamics**

Statistical thermodynamics deals with the changes that is hapening to the thermodynamic systems at molecular levels.

**Principles of statistics and probability**

To understand the equilibria, we should use a language that includes energy, entropy, enthalpy and free energy. Entropy is the most essential element of the statistical thermodynamics since it is a measure of disorder.

**Probability**

If N is the total number of possible outcomes, and nA the outcomes which fall into category A, then PA, the probability of the outcome A is

Below equation is the starting point of statistical mechanics. It defines the relation between entropy and the multiplicity of the microscopic degrees of freedom of a system by using the Boltzman constant, k. k= 1.380662 x 10-23 J/K.

The physical significance of k is the measure of the amount of energy that corresponds to the random thermal motions of the particles within the material.

(https://www.britannica.com/science/Boltzmann-constant)

S=k log W so states that the state that maximizes W also maximizes S.

For a sequence of N distinguishable objects, the number of different permutations W can be expressed in factorial notation

W= N(N-1)(N-2)….3.2.1 = N!

In general, for a collection of N objects with t categories, of which ni objects with t categoris, of which ni objects in each category are indistinguishable from one another, but distinguishable from the objects in the other t-1 categories, the number of permutations W is

Suppose that we have a thermodynamic system having two subsystems, A and B, with multiplicities WA and WB, respectively. The multiplicity of the total system will be equal to WAWB and Stotal=k lnWAWB = k ln WA + k ln WB = SA + SB.

Besides, is called Boltzmann distribution law which describes the energy distributions of atoms and molecules.

p(E)

Low temperature

High temperature

 E

Based on the Boltzmann distribution, states of lower energy are more populated than states of higher energy.

Boltzmann disribution law states that the probability of finding the molecule in a particular energy state varies exponentially as the energy divided by kBT.

N = N0 exp (-E/kBT)

Reference:

D. Winterbone and A. Turan , "Advanced Thermodynamics for Engineers", 1996, Butterworth-Heinemann.